RESEARCH

IN *SCIENCE* JOURNALS

Edited by **Michael Funk**

Artist's rendering of a neural synapse with active protein translation

NEUROSCIENCE

Sleep-wake cycles at mouse synapses

Analysis of the transcriptome, proteome, and phosphoproteome at synapses in the mouse brain during daily sleep-wake cycles reveals large dynamic changes (see the Perspective by Cirelli and Tononi). Noya *et al*. found that almost 70% of transcripts showed changes in abundance during daily circadian cycles. Transcripts and proteins associated with synaptic signaling accumulated before the active phase (dusk for these nocturnal animals), whereas messenger RNAs and protein associated with metabolism and translation accumulated before the resting phase. Brüning *et al*. found that half of the 2000 synaptic phosphoproteins quantified showed changes with daily activity-rest cycles. Sleep deprivation abolished nearly all (98%) of these phosphorylation cycles at synapses. —LBR *Science*, this issue p. 200, p. 201; see also p. 189

STRUCTURAL BIOLOGY

Mastering regulation

The mechanistic target of rapamycin complex 1 (mTORC1) is known as the master kinase, acknowledging its key role in integrating multiple signals to regulate cell growth. When nutrients are abundant, heterodimers of Rag, a class of small guanosine triphosphatase, bind to mTORC1 and recruit it to the lysosome. Here, other signaling pathways converge on the mTORC1 complex. Anandapadamanaban *et al*. determined cryo–electron microscopy and crystal structures of a RagA/RagC heterodimer. The structures, together with dynamic studies, explain the nucleotide states required for binding to mTORC1 and support a mechanism for conformational communication between the RagA and RagC subunits in the heterodimer. RagA/RagC binding causes no conformational change in mTORC1, which is consistent with the idea that mTORC1 must sense additional growth regulators before it is activated. —VV

Science, this issue p. 203

IMMUNOLOGY

Autoimmunity shows its CARDs

Both the adaptor protein CARD9 and loss of the kinase Lyn are associated with autoimmune disease, notably colitis and inflammatory bowel disease. Ma *et al*. found in mice that CARD9 amplified Toll-like receptor signaling and cytokine production in Lyn-deficient dendritic cells but not macrophages. Deleting the *Card9* gene or genes encoding Src-family kinases in dendritic cells prevented the development of Lyn deficiency–associated colitis in mice. Targeting CARD9 or its associated kinases may be a way to relieve inflammation in patients with autoimmune disease. —LKF

Sci. Signal. **12**, eaao3829 (2019).

MATERIALS SCIENCE

Twisting is cool

Rubber bands that are stretched and held in an extended shape for a while will extract heat from their surroundings as they are allowed to relax, owing to a reversal of stress-induced crystallization, which is an exothermic process. Wang *et al*. examine the potential for solid-state cooling of twisted fibers, along with configurations such as supercoiling, for materials including natural rubber, polyethylene, and nickel-titanium fibers. The cooling is related to the change in entropy of the material as it is mechanically deformed. —MSL

Science, this issue p. 216

CANCER

Dishing out treatment recommendations

The number of treatment options for cancer patients keeps expanding, but it remains difficult to predict which tumors will be sensitive to which treatments.

ILLUSTRATION: MAX IGLESIAS

Published by AAAS

Most patients thus receive treatment according to standardized protocols; some respond to treatment, but others only experience side effects. Ooft *et al*. developed a method of testing drugs in patient-derived organoids, which are biopsy-derived cells from individual patients grown in a dish. In a clinical study, the responses of organoids to the cancer drug irinotecan correlated with patients' responses, suggesting that screening in organoids could help avoid giving irinotecan to patients who would not benefit. —YN

Sci. Transl. Med. **11**, eaay2574 (2019).

ELECTROCHEMISTRY

A direct route to pure peroxide

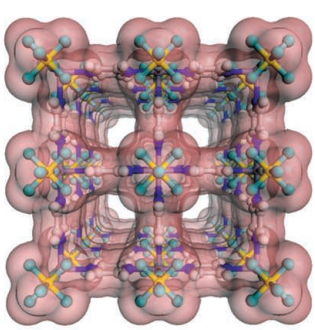
Despite the widespread use of hydrogen peroxide as an oxidant and disinfectant, its commercial synthesis still requires inefficient concentration and purification steps. Xia *et al*. now report an electrochemical approach to synthesizing pure peroxide solutions straight from hydrogen and oxygen. Using a solid-state electrolyte, they avoid contamination of the product solution by extraneous ions. Varying the flow rate of water through the electrochemical cell tunes the final concentration over a range from 0.3% to 20% by weight. —JSY

Science, this issue p. 226

GAS SEPARATIONS

Selecting for ethylene

Purification of ethylene from other gases produced during its synthesis, such as acetylene, ethane, and carbon dioxide, is an energy-intensive process.



Metal-organic framework with molecular selectivity

CREDITS: (LEFT TO RIGHT) CHEN *ET AL*.; AVALON/PICTURE NATURE/ALAMY STOCK PHOTO

Chen *et al*. use a mixture of microporous metal-organic framework physisorbents that are selective for one of these four gases. A series of sorbents in a packed-bed geometry produced ethylene pure enough for making polymers. —PDS

Science, this issue p. 241

ECOSYSTEM SERVICES

The future of nature's contributions

A recent Global Assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services has emphasized the urgent need to determine where and how nature's contribution matters most to people. Chaplin-Kramer *et al*. have developed a global-scale modeling of ecosystem services, focusing on water quality regulation, coastal protection, and crop pollination (see the Perspective by Balvanera). By 2050, up to 5 billion people may be at risk from diminishing ecosystem services, particularly in Africa and South Asia. —AMS

Science, this issue p. 255; see also p. 184

RADIO ASTRONOMY

Probing a galaxy halo with a radio burst

Fast radio bursts (FRBs) are millisecond flashes of radio emission from distant galaxies. It has only recently become possible to locate single bursts precisely enough to determine the host galaxy. Prochaska *et al*. have observed and localized a FRB using a radio interferometer. The line of sight to the host galaxy coincidentally passes through the outskirts of a closer foreground galaxy. By analyzing the propagation of the FRB, the authors put constraints on the density and magnetization of gas in the outskirts of the foreground galaxy. The technique provides complementary information to existing methods using background quasars. —KTS

Science, this issue p. 231

IN OTHER JOURNALS

Edited by **Caroline Ash** *and* **Jesse Smith**

PLANT ECOLOGY

Plants, soils, and climate

Environmental change is rarely straightforward in its consequences for natural communities, because of the complexity of spatial and temporal interspecific interactions. Rasmussen *et al*. experimentally studied the effects of temperature and moisture variation on the growth patterns of a perennial herb (*Plantago lanceolata*) and its associated soil microbial community. They used a reciprocal multifactorial design, using plants and soil communities from three different habitats in Sweden. Although warming and increased moisture had a generally positive effect on plant growth, the strength of the response depended on the origin of the plants, as did the responses of root-associated fungi. Thus, climate change may be expected to produce complex patterns of variation in plant-soil interactions, which may be difficult to predict. —AMS

J. Ecol. 10.1111/1365-2745.13292 (2019).

The perennial herb *Plantago lanceolata*

MATERIALS SCIENCE

Glassy carbon for maximum impact

Materials designed for impact absorption need to be able not only to cope with high-stress deformations but also to accommodate high strain, as the energy absorbed is the integral of the stress-strain response. Although lightweight designed materials, such as those based on trusses, can show high strength or high deformability, they usually cannot do both. Guell Izard *et al*. devised an architected material with smooth interconnected surfaces, similar to a shell, that

ALSO IN *SCIENCE* JOURNALS

Edited by **Michael Funk**

CELLULAR NEUROSCIENCE

From trafficking to maintenance

Neurons are remarkably polarized in that proteins made in the cytosol often need to travel many tens or hundreds of cell body lengths along axons to their sites of action in the synapse. Axonal transport of these components is driven by molecular motors along axonal microtubules. Guedes-Dias and Holzbaur review the cell biology of axonal transport and highlight the roles this fundamental process plays in organismal health. —SMH

Science, this issue p. 199

IMMUNOLOGY

Some naïve T cell fates are sealed

Tissue-resident memory T (T_{RM}) cells constitute a subpopulation of memory cells that reside in tissues instead of recirculating. $CD8^+$ epithelial TRM (eT_{RM}) cells, which occupy the epithelium of sites like the skin, require transforming growth factor–β (TGF-β) for their development. Mani *et al*. found that α_V integrin–expressing dendritic cells, which activate and present TGF-β, are key (see the Perspective by Farber). Surprisingly, this interplay did not occur in the skin or draining lymph nodes during T cell priming. Rather, resting naïve $CD8^+$ T cells interacted with α_V integrin–expressing migratory dendritic cells during immune homeostasis, reversibly preconditioning them to become eT_{RM} cells upon activation. A potent cytokine is thus controlled in a context-dependent manner and preimmune T cell repertoires may be less uniform than previously presumed. —STS

Science, this issue p. 202; see also p. 188

SUPERCONDUCTIVITY

Modulating superconductivity

Strain can have considerable effects on the electronic properties of materials. For instance, the temperature at which a material becomes superconducting—the critical temperature—can be tuned by varying strain. Bachmann *et al*. used focused ion beam milling to fabricate microstructures of the superconductor $CeIrIn_5$ on sapphire substrate. A difference in the thermal contraction coefficients of the two layers induced nonuniform strain upon cooling of the sample, leading to large gradients of the critical temperature. This approach can be used in other materials and may enable fabrication of superconducting circuitry without physical junctions. —JS

Science, this issue p. 221

SUPERCONDUCTIVITY

Unconventional oscillations

At sufficiently low temperatures, superconductors expel an applied magnetic field. However, if the topology of the superconductor is nontrivial—for example, if there is a hole in the sample—there can be a nonzero magnetic flux inside the hole. This flux can only take certain discrete values, and the superconducting critical temperature has maxima at the corresponding values of the magnetic field. Li *et al*. studied these so-called Little-Parks oscillations in superconducting rings made out of polycrystalline thin films of β-Bi_2Pd. They found that the phase of the oscillations was shifted by π compared with oscillations observed in most superconductors, as predicted for certain unconventional pairing symmetries. —JS

Science, this issue p. 238

SURFACE CHEMISTRY

Imaging a chemisorption process

At low temperatures, a molecule may adsorb to a surface only through weak forces (physisorption), and only upon heating and overcoming an energetic barrier does it form a strong covalent bond (chemisorption). Huber *et al*. imaged this transition for an atomic force microscopy tip terminating in a carbon monoxide molecule. Although the oxygen atom of the tip is normally considered to act like a rare gas atom, interacting only through van der Waals interactions, at short distances directly above a transition metal atom, it transitions to a strongly interacting chemisorption state. —PDS

Science, this issue p. 235

NEUROSCIENCE

Fine control of brain $GABA_A$ receptors

$GABA_A$ (γ-aminobutyric acid type A) receptors are ligand-gated anion channels that mediate fast inhibitory transmission in the mammalian brain. Han *et al*. investigated if a protein called SHISA7 was involved in regulating $GABA_A$ receptor expression and function (see the Perspective by Rudolph and Moss). SHISA7 was found at GABA-releasing synapses, where it interacted with $GABA_A$ receptors, controlled receptor concentration at the synapse, sped up receptor deactivation kinetics, and modulated some behavioral properties of benzodiazepines. SHISA7 thus affects surface expression, gating kinetics, and pharmacology of $GABA_A$ receptors in the brain. —PRS

Science, this issue p. 246; see also p. 185

NEUROSCIENCE

An inhibitor causes neuronal excitation

Glycine is thought to be primarily an inhibitory neurotransmitter. However, it also acts as a coagonist on excitatory *N*-methyl-D-aspartate (NMDA) receptors. Otsu *et al*. examined the function of the NMDA receptor subunit combination GluN1/GluN3A in the medial habenula (MHb) of adult mice. This NMDA receptor subunit combination in MHb neurons is activated by glycine released from astrocytes. Activation of GluN1/GluN3A NMDA receptors causes depolarization and increased spiking of MHb neurons. Reducing GluN3A receptor subunit levels in the MHb blocks conditioned place aversion. —PRS

Science, this issue p. 250

INNATE LYMPHOID CELLS

Keeping track of time

A number of bodily functions, from feeding to sleeping, are regulated by circadian clocks. Teng *et al*. and Wang *et al*. report that expression of several genes in intestinal group 3 innate lymphoid cells (ILC3s) in mice is synchronized to the time of day. To probe the role of clock proteins in regulating ILC3 functions, the two groups studied mice lacking distinct clock proteins, BMAL1 and REV-ERBα. The loss of these clock proteins resulted in decrease in the number of intestinal ILC3s, but these cells produced higher levels of certain cytokines. How clock proteins fit within the larger network of transcription factors regulating development and gene expression in ILC3s remains to be seen. —AB

Sci. Immunol. **4**, eaax1215, eaay7501 (2019).

PHASE-CHANGE MEMORY

Getting more bits out of PCRAM

Phase-change random access memory (PCRAM) has the ability to both store and process information. It also suffers from noise and electrical drift due to damage that accumulates during the cycling process. Ding *et al*. developed a phase-change heterostructure where a phase-change material is separated by a confinement material, creating an alternating stack (see the Perspective by Gholipour). This architecture results in ultralow noise, lower drift, and stable multilevel storage capacity, which are potentially useful for new forms of computing. —BG

Science, this issue p. 210; see also p. 186